1. IC3.1: User Impacts

Instructor Notes: Welcome to the AWOC Winter Track Instructional Component 3, Lesson 1. This presentation, entitled Significant Impacts to Users, should last approximately 25 minutes. While much of this lesson may cover material that you've seen before, some of the content contains information you might not have thought of or have been exposed to before.

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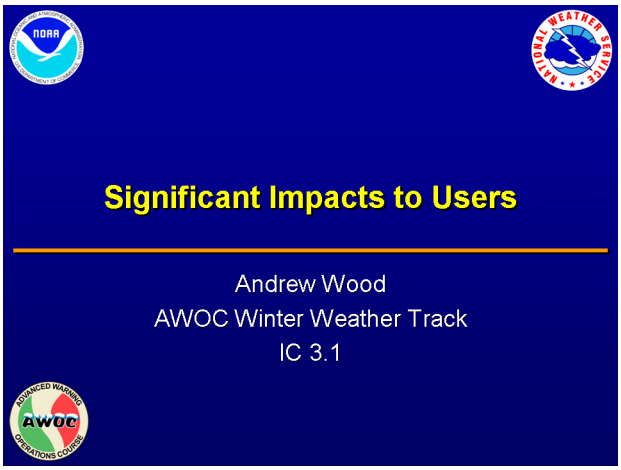

2. Collaborators and Reviewers For This Lesson

Instructor Notes: This IC is the end result of the input and effort of several people. Everyone listed here helped in some capacity, such as helping to define the scope and outline of the lesson, assisting in the development of lesson content, or in reviewing the draft and final presentations. All of their efforts are greatly appreciated.

Student Notes:

3. Learning Objectives for IC 3, Lesson 1

Instructor Notes: There are three learning objectives for this lesson. The first objective is that by the end of the lesson, you should be able to identify the weather information that is most critical to communicate to users for their mitigation efforts. Second, you should be able to explain how some of the variations in these variables can have different impacts on users. Lastly, you should be able to identify how certain "sub-advisory" winter weather events can have significant societal impacts.

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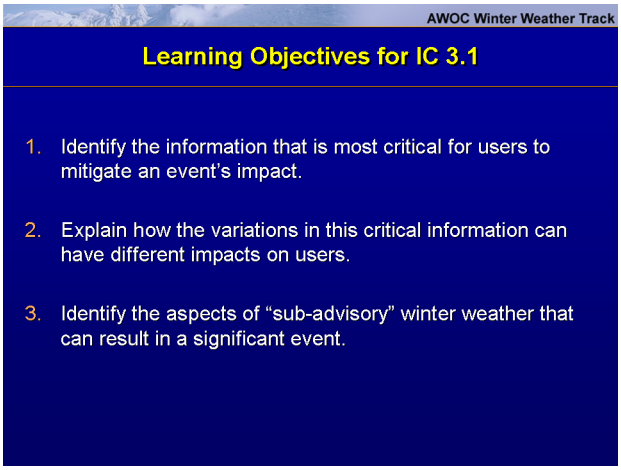

4. Why Winter Weather Events Are Critical to So Many Users

Instructor Notes: It's understood that winter weather events have significant impacts to users throughout a majority of the country. Large sections of the US (including almost every state) average at least one day of snow or other freezing precipitation type per year. Approximately 70% of the US land area receives at least 5" average snowfall each year, affecting nearly 70% of the US population (FHWA, 2005) with significant societal impacts. For instance, in 1999 approximately 63,000 injuries and 680 deaths in traffic accidents occurred when snow and ice were present on roadways (Mahoney, 2003). In 2001, those numbers were 95,000 and 1,100, respectively (FHWA, 2005). As a result of the large numbers of people impacted, there are a multitude of issues that our users must address to mitigate the impact of winter weather events.

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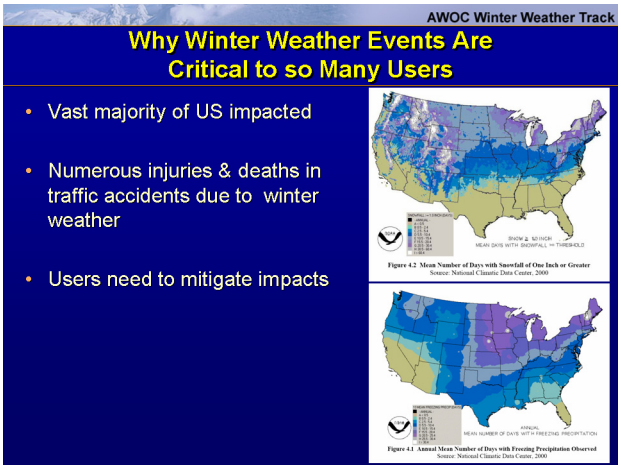

5. Critical Information That Users Need to Mitigate a Significant Event

Instructor Notes: Generally speaking, most users receive "enough" information about winter weather events. In fact, many think they receive too much information. That's why it is important that we emphasize the most critical information that our users need in our products. Timing information is important, such as when an event will start, when it will stop, and when will any significant changes occur during the event. Other topics users might have questions on include: What will the expected precipitation intensity, type, and accumulation be? Will strong winds result in blowing snow or will there be any other reduced visibility issues? Lastly, what will the ground and near-ground air temperatures be like? All of these variables can significantly impact the severity and our users' experiences of an event. They need to know which will be the most important, and may define, the upcoming event and why.

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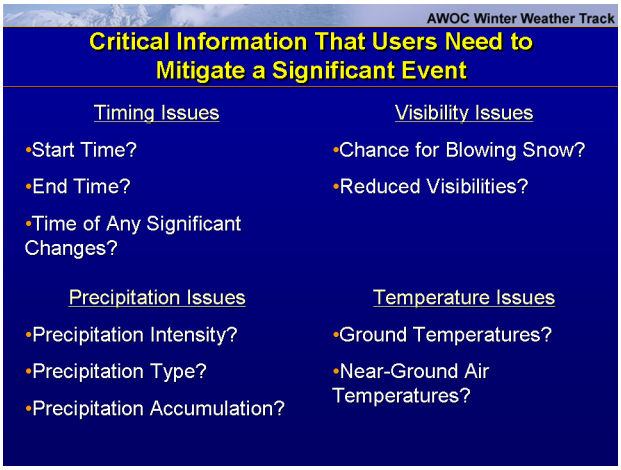

6. Impacts from Diurnal Variations

Instructor Notes: One reason that timing impacts are important are diurnal variations. Ground and near-ground temperatures are just one example of a diurnal variation that can greatly influence an event's severity and impacts. People generally understand the more mundane stuff, such as paved surfaces getting warmed up in sunny and partly cloudy conditions. They are less likely to know about how different weather phenomena are affected by the diurnal cycle. Examples include freezing rain, freezing drizzle, and lake effect snow showers, all of which have a diurnal maximum in the pre-dawn and early morning hours (Cortinas et al., 2004; Strapp et al., 1996; Kristovich and Spinar, 2005). Occasionally taking a moment to explain these dependences to our users, and how they can impact the significance of an event, is beneficial to them. Society is diurnal, too. Winter events that occur during daylight hours are more likely to affect travelers, commuters, and most businesses in some way. While daytime events generally impact more people, significant impacts can occur during nocturnal events. These impacts range from getting less ground truth reports in the middle of the night to problems affecting a variety of commercial enterprises. Impacts to commerce include commercial truck drivers tendency to drive at night because there is less traffic, many ground and air shipment companies transporting packages at night, and even 24-7 grocery and convenience stores receiving and stocking inventory at night.

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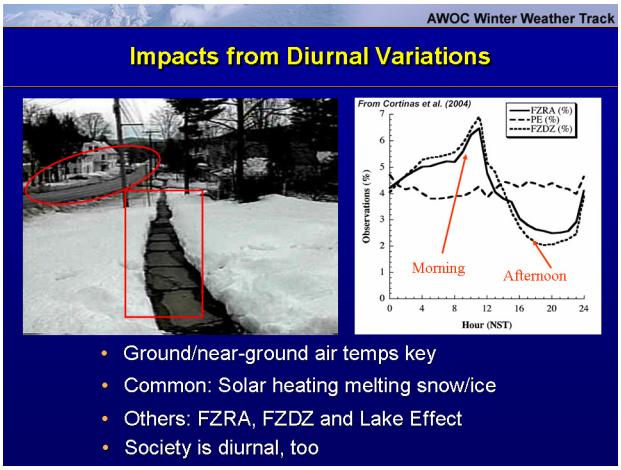

7. Information on Seasonality Impacts

Instructor Notes: Besides time of day, there are also timing impacts due to the seasonality of the event. Often the first storm of the season each year catches people off guard, even if the event only results in an inch or two of accumulation (DeVoir, 2004). Mills and Andrey (2002) suggest that there is a heightened road collision risk during the first snowfall of the season because people are out of practice driving in those conditions. If the first event is unseasonably early it can make matters worse if there are still leaves on trees in the area. While total accumulations are often smaller on roadways, these events usually result in a significant increase in damage to trees, power lines, and related dam-

age due to falling tree limbs. Heightened wording in products and forecasts for these events can be helpful to users.

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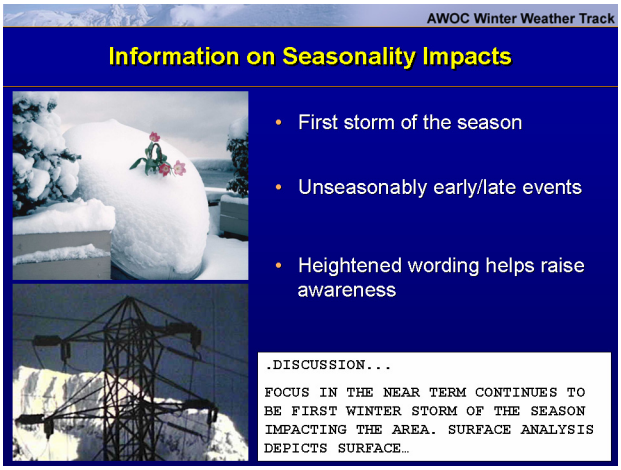

8. Information on Precipitation Intensity Variations

Instructor Notes: Snow accumulation values are the most common precipitation info available to users. Just as important, but less reported, is precipitation intensity. The problem is snow intensity can often be a better indication of event severity. After all, 6” of snow in 3 hours will usually produce more societal impacts than 6” in 12 hours. HPC has experimental societal impact products available on-line showing the probability of snowfall intensities greater than 1”/hr., 2”/hr., and 3”/hr. that you might find helpful. When discussing intensities with users in mind, you don’t have to shy away from discussing technical details such as strength of forcing, precipitation microphysics, etc. Some users may get a little intimidated by such discussions, many of our high-end, regular users depend on this information when it is clear and concisely stated. The consistent communication of precipitation intensity information to users is vital, especially when changes in snow intensity occur unexpectedly. The most difficult traffic problems are often caused by changes in snow intensity, precipitation type changeover, etc. These changes can lead to blinding snowfall, rapidly deteriorating road conditions, and increased driver anxiety and confusion (DeVoir, 2004).

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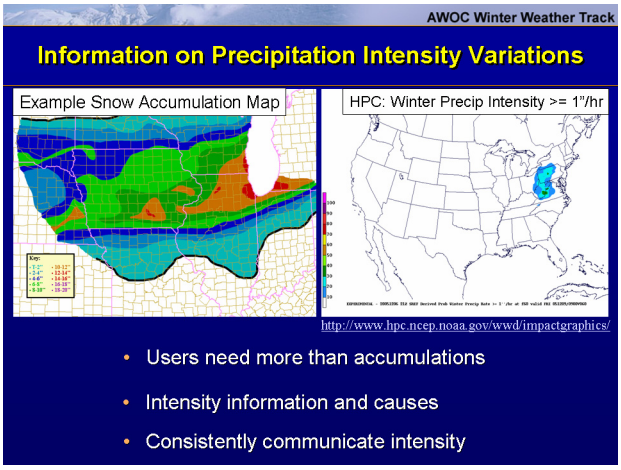

9. Greatest General Risk vs. Catastrophic Risk

Instructor Notes: Risks from winter event impacts will vary from region to region. What may seem like extreme winter precipitation totals in one area may seem like no big deal elsewhere, and vice versa. After all, a 12" snow in the southeast US can quickly become catastrophic while in other parts of the US that snowfall may only be an inconvenience. It's important to remember that just because a region has a greater likelihood of snow or ice occurring, that doesn't mean that the same region has the greatest risk of a significant, or even catastrophic, event in terms of impacts. For example, days with freezing rain generally occur twice as frequently in the northeast US than in other areas in the central and eastern US (Cortinas et al., 2004). But, between 1949 and 2000, the Deep South had the greatest percentage of ice storms with an excess of 1 million dollars in insured property losses (using 2000 USD; Changnon, 2003). The duration of most continuous freezing precipitation events is less than 2 hours, but nearly 10% of events last longer than 4 hours (Cortinas et al., 2004). These longer events are the ones most likely to result in significant damages in terms of dollars and, hence, generally cause the greatest societal impacts. It's important in our products to clearly differentiate between a common event and a potentially more damaging event (when our confidence is high that such an event will occur).

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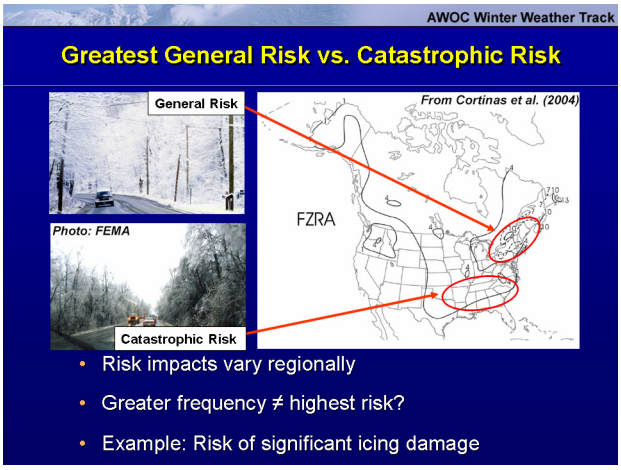

10. Communicating Changeover Timing and Most Likely Scenarios

Instructor Notes: Users need to know if a change in precip type is possible, when it will likely occur and what type of changeover will likely happen. Since the changeover region in most systems is usually long and narrow, often resulting in short transition periods, user mitigation is closely dependent on knowing the correct timing. In the case of events where there is a prolonged transition between types, or even multiple changes in type, it is critical that the possibility of such a changeover be communicated to users as accurately as possible. Giving users a "heads up" to whether a forecast changeover is common or uncommon, what the range of possibilities are, etc., can also help. Graphical products, like the Graphicasts shown here can be a great way to communicate changeover timing. These graphics are taken from two different times during a freezing rain event. The first image highlights the rain showers moving in and when the freezing precipitation should begin. The second graphic is for several hours later in the same event, showing what freezing has occurred and where future freezing is likely.

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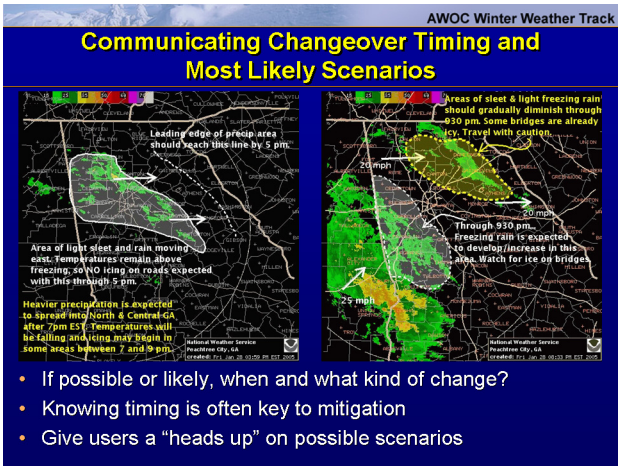

11. Rapid Temperature Changes: The Two Extremes

Instructor Notes: Rapid temperature changes can result in two very different, but significant, user impacts. The first change we'll discuss is a rapid temperature decrease. Whenever there is winter precipitation falling, or has recently fallen, a rapid drop in near-ground temperature (especially if the temperature drop is not well communicated in forecasts or other products) can cause nightmares for ground transportation. Even drops of 5-10 degrees F that occur more quickly than forecast can be problematic. Such a situation could result in a road treatment strategy no longer being effective at the lower temperature. One such event, highlighted by Wolf et al. (2004), resulted in road crews having to continually treat roads much longer than initially anticipated (resulting in much greater costs) until the sun helped melt the snow and ice on the roads (several hours after the precipitation had ceased). Rapid warm ups can also have substantial user impacts. Rapid warm-ups during "January thaws" or later on in Spring can result in everything from isolated thin ice accidents to flooding, structural damage to bridges (especially in the case of ice jams), and other related impacts. The magnitude of impacts from such warm-ups depend on how quickly they occur, how thick the ice is on lakes and rivers, whether the ground is still frozen (i.e., more runoff), and if there is sufficient lead time that mitigation efforts can be implemented prior to the melt.

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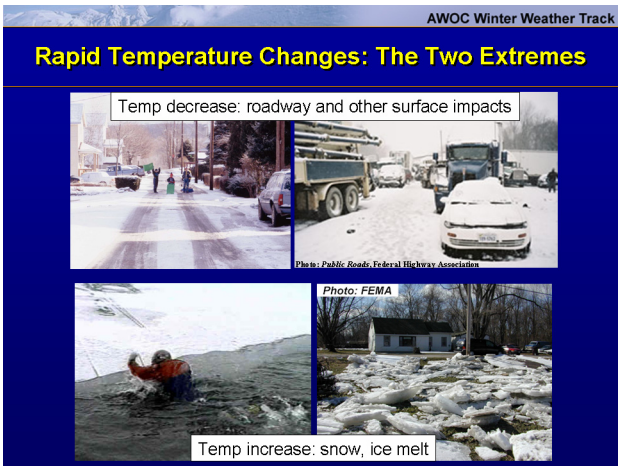

12. Timing Impacts: Relationship to Transportation

Instructor Notes: Earlier we discussed how impacts of events will be greater during the day, especially weekdays, then at night. Traffic volume is at its highest during the morning and evening "rush hour" and, to a lesser extent, on weekend afternoons. Events occurring at these times have the greatest potential for impacts, especially for more marginal events and in areas that regularly experience winter weather. High impact events are also possible during the week at midday if the event is stronger than forecast, businesses and schools simultaneously release early, and a dramatic increase in traffic volume occurs at the height of the storm (Call, 2005). Common travel days around many holidays will have greater traffic volume than on "non-holiday" days. Similarly, weekend

traffic in December, especially around major shopping areas, will be substantially higher than most other weekends during the year. Other special events (i.e., sporting events, New Year's celebrations, etc.) can also significantly enhance traffic volume in certain areas at normally low volume times. It is important to keep these high volume times in mind because most road maintenance crews treat roads so that they are in optimal condition for these times. This strategy usually requires them to treat interstate highways and other major routes (or snow routes) in the few hours prior to rush hour. That will allow enough time for the chemicals to dissolve or dry depending on their treatment strategy. So, when it comes down to timing impacts, any forecasts errors (or even good forecasts communicated poorly) will have higher sensitivities just prior to and during these high volume periods of the day.

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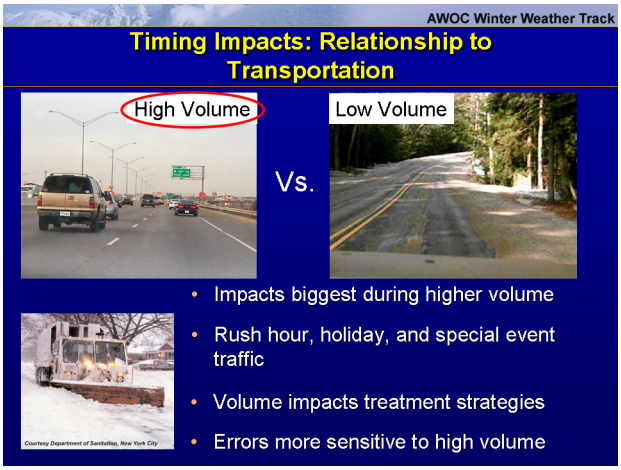

13. Some Statistics on the Impacts of Winter Precipitation on Transportation

Instructor Notes: The accumulation of winter precipitation can be considered the primary adverse weather condition for all facets of the transportation sector (Zubrick, 2004). For instance, average arterial road speeds decline 30-40% on snowy or slushy pavement; Freeway speeds are reduced by 10% in light snow and 40% in heavy snow (FHWA, 2005). In 2001, 20% of weather-related vehicle accidents occurred on snowy or slushy roads, 1/3 of which occurred after frozen precipitation stopped falling (FHWA, 2005). Knapp et al. (2000) found that both snowfall intensity and time of exposure to winter conditions had a positive relationship to crash frequency. Clearly, frozen precipitation accumulation on roadways is important.

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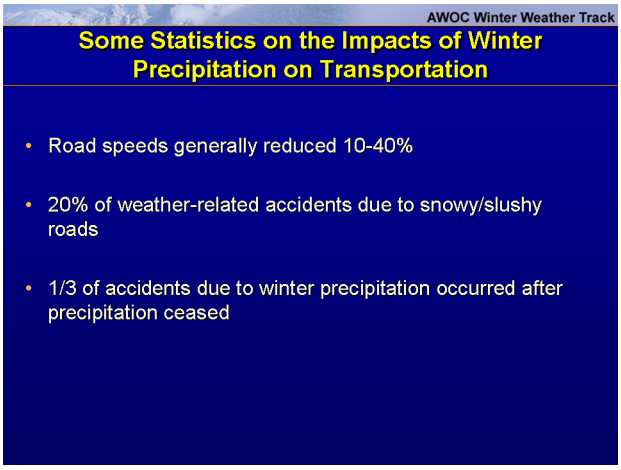

14. Impacts to Aviation: Observations of Freezing Rain and Drizzle

Instructor Notes: The impacts of winter precipitation extend past road transportation. In-flight icing is one of the biggest issues with regards to aviation, and more money is spent researching improvements to in-flight icing forecasts than any other aviation forecast issue. While in-flight icing observations are less numerous then they are at the surface, research indicates ice pellets, freezing rain, and freezing drizzle observed at the ground provide a strong indication of in-flight icing conditions (Bernstein et al., 1997, 1998; Bernstein and McDonough, 2000; Hanesiak and Stewart, 1995; Zerr, 1997). This relationship between surface and in-flight icing conditions is especially important with regards to freezing drizzle, which can be difficult to detect at most distances from the WSR-88D even in clear air mode (Zubrick, 2004).

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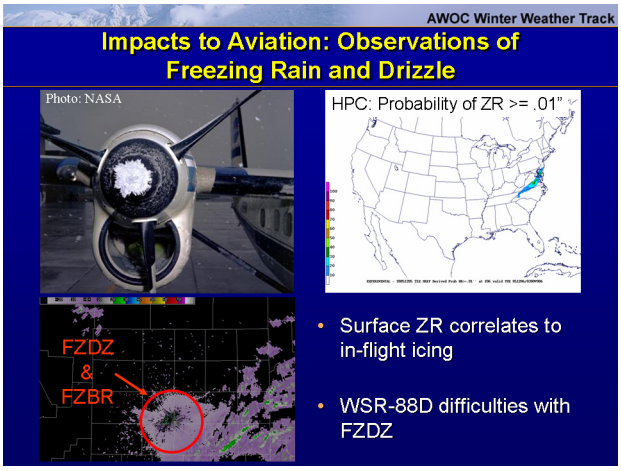

15. Reduced Visibilities: Relationship to Transportation

Instructor Notes: Visibilities can be quickly reduced by large aggregate snow flakes or even heavy sleet. Many large, multiple-vehicle traffic accidents occur during events where accumulations were generally light, but the snow's intensity and winds resulted in localized white-out conditions (DeVoir, 2004). Plus, in some regions with strong winds and significant, powdery snow packs, it is possible for near blizzard conditions to exist when there is little or no snow falling in that area. HPC's web site has forecast graphics available on-line for users (and forecasters) to be better aware of such visibility hazards. Knapp et al. (2000) found that total snowfall and the square of the maximum wind gust speed had an inverse relationship to traffic volume (with an average volume reduction of ~30%). However, wind gust speed had no significant relationship to accident rates. The events included in the study had more significant durations and intensities with (snow-falls of at least 4 hours with estimated intensity of at least 0.20" LE/hr.) then the average event. When these results are compared to other meteorological case studies and research (DeVoir, 2004;Zubrick, 2004; and others), it can be inferred that reduced visibil-ities may have a bigger impact on road traffic during minor events when more people are out on the roads.

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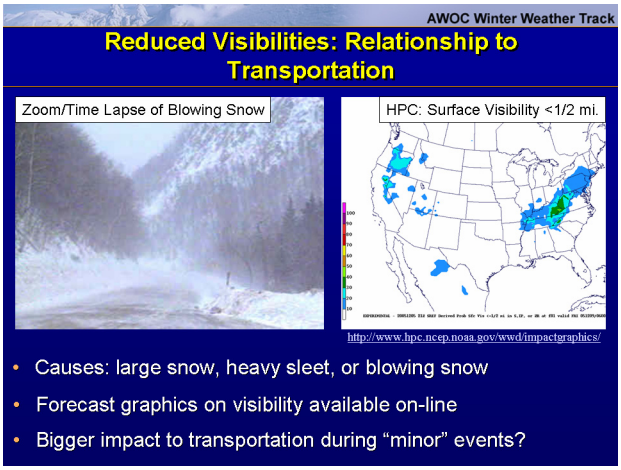

16. How Surface and Air Temperatures Can Impact Ground Transportation

Instructor Notes: Small changes in ground and near-ground air temperatures can play a major role in impact severity. Events that might otherwise be significant, or even cata-strophic, can have minimal impacts when ground temperatures are above freezing. There is currently a large volume of observations available for different roadway sensors and local mesonets that can provide information about ground temperatures. You have to be careful what you're looking at, though. There can be some subtle differences (such as bare soil vs. sod ground temperature) that can have a significant impact on data you

are looking at. For instance, a 10 cm sod temperature probe may be measuring a 10 cm ground temperature in the low 40s, but the surface temperature is really around freezing (with snow sticking to the ground in places). Similarly, road sensors will read warmer nighttime temperatures than bridge sensors. Road Weather Information System (RWIS) sites also tend to record lower wind speeds than might be expected, especially when winds are below 12 kts because these sites usually are less exposed to the wind (Pisano et al., 2004).

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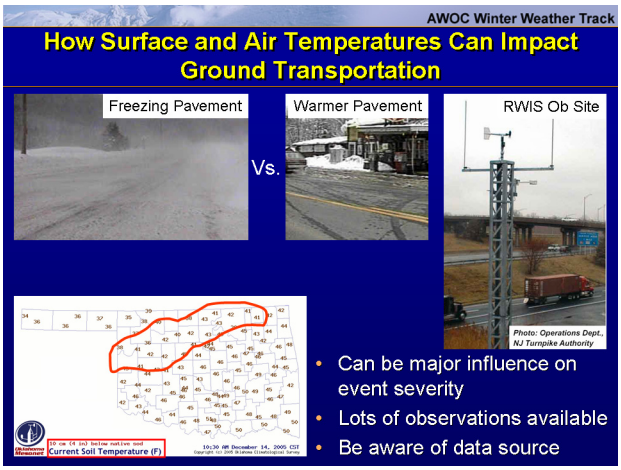

17. Learning Interaction 1

Instructor Notes: Take a few moments to complete this interactive quiz.

Student Notes:

18. Importance of Sub-Advisory Events

Instructor Notes: Recent research has focused more and more on evaluating the impacts of high-end snow events on people to rate a storms significance (Kocin and Uccelini, 2004; Call, 2005). From a user's standpoint, however, "minor" (meteorologically speaking) winter weather events can still be very significant. These "sub-advisory"

events occur much more frequently than advisory or warning criteria events and may not arouse much public concern. However, if the possibility of adverse conditions exist in such an event, even for only 5-10 minutes, they can have adverse consequences on transportation. This is especially true if they occur during high traffic volume times with little advance warning. These subtle, light winter events will generally have short lead times. The forecast models may not pickup on specific details of the event until 12 hours or less prior to verification (Zubrick, 2004). Another aspect of these events that is challenging is this: what products do you issue? It is difficult to issue a Watch, Warning, or Advisory product if you know criteria will not be met. Often Short Term Forecasts do not receive the same media attention that WWA products do, and may not prove effective. A quick look at a daily forecast by the public probably will not provide them with sufficient information to avoid potential impacts (DeVoir, 2004). In events like these, communicating intensity and duration of snowfall is vital. Some research suggests mitigating the impacts of these “routine adverse weather” events would yield the biggest economic impacts (Colgan, 2005). It is crucial to consistently use terminology to distinguish high intensity events from more ordinary “snow showers”.

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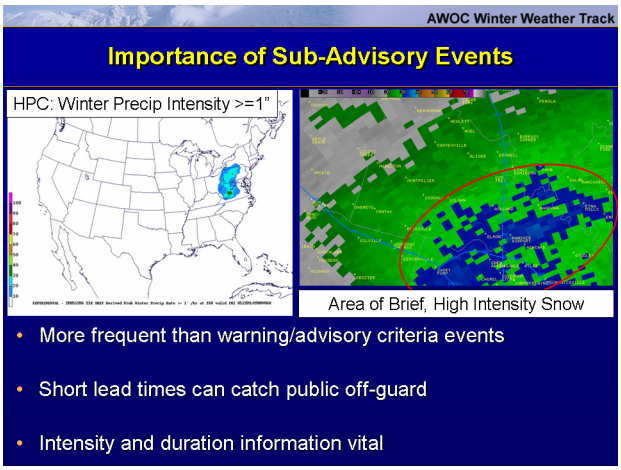
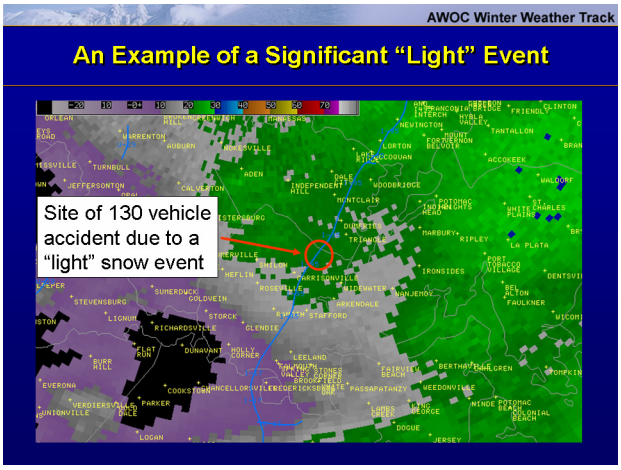


19. An Example of a Significant “Light” Event

Instructor Notes: This loop of radar images show an example of a significant sub-advisory, or “light”, event. The loop is for a 40-minute period during a two-hour event that produced 2-3” of snow over northern VA. In the highlighted area, there was a multi-vehicle crash between Garrisonville and Dumfries along I-95 involving over 130 vehicles during “white out” conditions. During this two-hour event, there were at least 3 other multi-vehicle crashes involving at least 20 vehicles in the area between Washington D.C. and Richmond, VA.

Student Notes:



20. "Plowable" Snows

Instructor Notes: Another way to look at "sub-advisory" events is whether or not it is a "plowable" snow. While road crews may be sent out to chemically treat roads when there's only a trace, plows may not be utilized unless a significant amount of snowfall is expected. Plowing represents an added cost for road maintenance as well as private citizens who have contracts to have driveways and parking lots plowed based on accumulation totals. Just like advisory and warning criteria, the thresholds for plowing snow are variable across the US. A common threshold for secondary and rural roads is 3" (Hallowell and Blaisdell, 2003), while highways and primary snow routes will likely have a lower threshold because of their Level-of-Service (or LOS). Many major cities have the goal of keeping their designated snow routes as snow free as possible during most events. These threshold values will vary regionally due to climatology, from city to city (due to size), and during the day due to traffic volume. In CWAs where there is generally a low frequency of winter weather events (say 5 or less on average each season), there are likely to be limited resources for plowing and treating roadways. These areas are likely to have a greater disparity between "plowable" thresholds for primary snow routes and other roads. For example, Charlotte, NC (which averages under 7"/yr. of snow) has in their winter weather plan that they will not plow most roads until accumulations reach at least 4" (FHWA, 2005).

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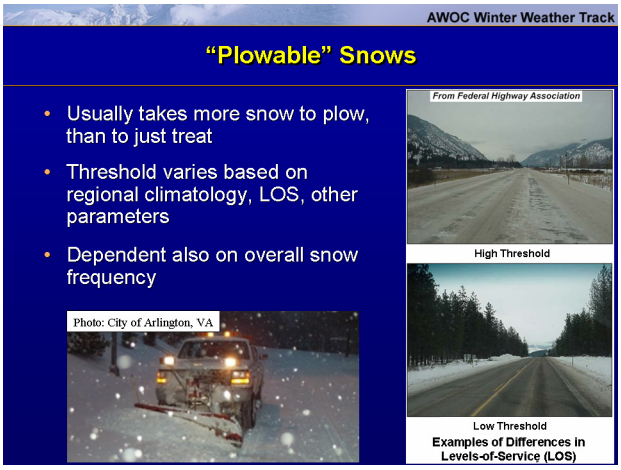

21. Black Ice and Other Freezing of Residual Moisture

Instructor Notes: Another adverse condition that falls into the "sub-advisory" category is the freezing of residual moisture on roadways (more popularly known as "black ice"). It is important to remember that "black ice" or similar conditions can be caused in many ways (i.e., freezing rain, ice fog, or even frost or freezing of dew on road surfaces). Many times patches of black ice can form simply because there is just enough traffic to melt a very light snow as it falls, but not enough to prevent it from refreezing. Remember that nearly 1/3 of winter weather related automobile accidents occur after precipitation has stopped. Black ice is a likely cause of many of those accidents, making it. Special Weather Statements can be very useful products to issue if the conditions for black ice formation are clearly evident. The problem is that most of the time black ice will form when there is little advance warning of these conditions.

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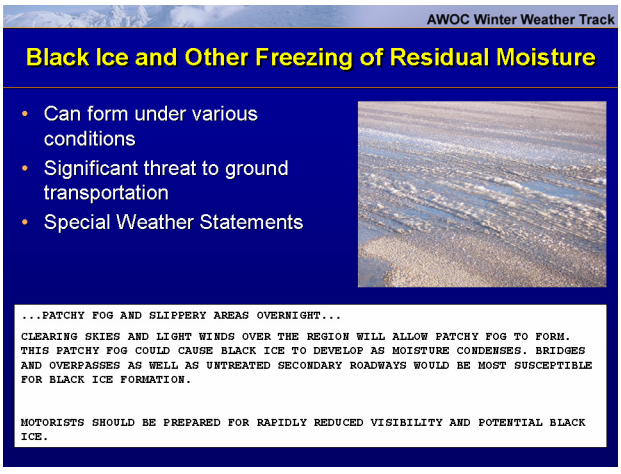

22. How Much Ice Does it Take for "Icy" Conditions

Instructor Notes: So how much ice does it take to create treacherous conditions? Well, not very much. Laboratory testing has shown than the grip between tires and asphalt is

dangerously reduced when ice exceeds 50 micrometers in thickness (Nicolas, 1996). During a typical light freezing rain event (say ~1 mm/hr.), it only takes a few minutes for that much ice to accumulate (Partanen et al., 2003). That means light precipitation events with as little as 0.1 mm/hr. can be important, from a user's perspective, if there is a chance for freezing on roadways. Even a single layer of snowflakes can reduce friction significantly and require treatment (Mahoney, 2003). As with other "light" events, communicating the potential threat to users is critical.

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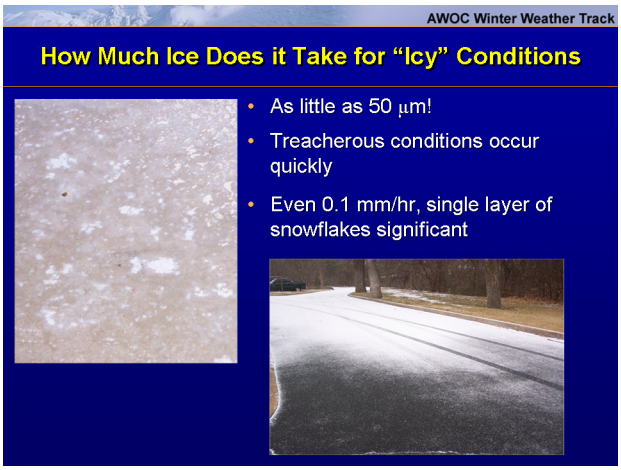

23. Learning Interaction 2

Instructor Notes: Take a few moments to complete this interactive quiz.

Student Notes:

24. Concluding Points on Impacts to Users

Instructor Notes: From a user's perspective, the need for information about a future or occurring event varies depending on the event and the potential impacts. Most users feel they receive too much weather information, so any way that we can clarify what the main threats of an event are can be helpful to them. It's important to communicate this infor-

mation as clearly as possible, highlighting particularly important characteristics of the event. Users also find it helpful to know if events are unusual or uncommon, so that they can adjust their preparations accordingly. Even just providing some value added information for the first winter event of the season can be helpful to them.

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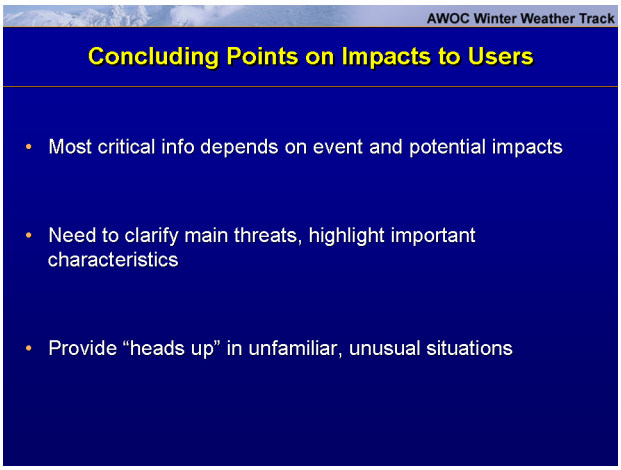

25. Concluding Points on Impacts to Users (Cont.)

Instructor Notes: Transportation impacts of winter weather events are probably most commonly felt throughout society. Of all the meteorological factors, ground and near-ground air temperatures are as crucial as any other when looking at impacts to ground transportation. When everything else is equal, above or below freezing ground temperatures could mean the difference between minimal or severe impacts. It's also important to characterize "light" events in detail to users. These events are much more frequent than warning or advisory criteria events, and they can have just as much of an impact.

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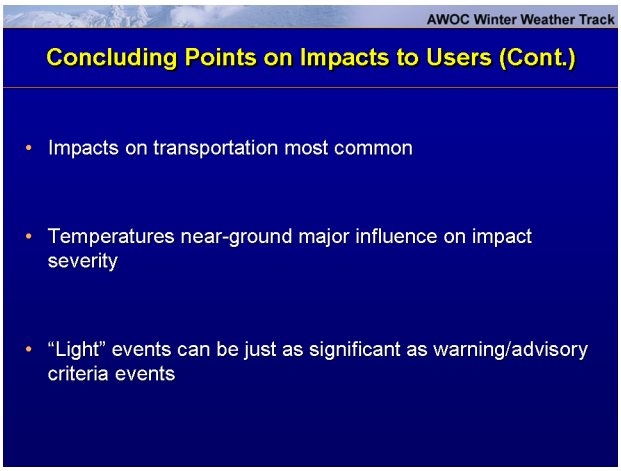

26. References Cited in This Lesson

Instructor Notes: This slide contains a list of all the references cited in the slides, mentioned by the speaker, or placed in the speaker notes. The full references are listed at the end of the student handouts for IC 3, lesson 1.

Student Notes:

27. Have any Questions????

Instructor Notes: If you have any questions about this lesson, first ask your local AWOC facilitator. If you need additional help, send an E-mail to the address provided. When we answer, we will CC your local facilitator and may consider your question for our FAQ page. We strongly recommend that you take the exam as soon as possible after completing Lesson 3.

Student Notes: